How to Plant and Cultivate An Orange Orchard

A Summary of the Main Points

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Citrus Fruit Culture

This manual is prepared in order to put into the hands of those who are planting orange trees this year the best information available for the making of profitable orange orchards. It can not be comprehensive, but it gives the main points in regard to selection of lands, preparation of lands, distances for planting, when and how to plant, and how to prune, methods of cultivation, diseases, insects and remedies.

It must be borne in mind that the industry in Texas is a new one. There has been little time yet to gather any comprehensive data, and few from whom to gain information as to how they have made profitable orchards. The climate, rainfall, soils and methods of cultivation vary greatly in the narrow confines of the orange belt. All these points must be borne in mind. In view of the newness of the industry, and the consequent lack of authentic horticultural information, each planter must himself become an experimenter, watch closely his methods and those of his neighbor, and learn to follow out what seems to give best results.

The growing of fine citrus fruits is the most profitable of all lines of horticulture. It gives highest returns per acre. Naturally it requires the biggest outlay, not necessarily of money, but of brains, from the time the grounds are selected till the fruit is on the market. Each point must be studied; each combination of soil, climate, variety, cultivation, must be studied, in the light of the experience of others and as an every day proposition of the orchard grower. With the right sort of care the returns will come and they will be big. But no orange orchard will grow of its own accord. No man expecting an orange orchard, and a profitable one, as the result of his planting may expect to do less than put with his ground and his trees the very best quality of brainwork that he can give.

CLIMATE AND RAINFALL.

It may be stated that in all regions where there is sufficient moisture, rainfall or irrigation, and the temperature does not rise above 100 or fall below 18 degrees above zero citrus fruits may be grown. Within these limitations, however, are localities that will not produce fruit to any extent worth while. Where the rainfall is too great, or at the time when the fruit is maturing, or the vegetable growth is too luxuriant little fruit may be expected. Along the Texas-Louisiana coastal belt, however, there is not too much rainfall for the growing of fine fruit, and in the regions further west and south in this belt, where the rainfall is not more than 30 inches per year there is still enough without irrigation, and in the southwestern part of the belt irrigation can be practiced. The coastal belt of these two States, back for a hundred miles from the gulf, may safely be regarded as an orange producing country. With good soil, proper varieties, and careful culture exceedingly profitable orange orchards should be developed within this area.

SOILS.

Citrus trees are exceedingly variable, and consequently will adapt themselves to almost any kind of soil in which they will grow. The quality of the fruit, however, is modified by the soil and the rainfall. Rich, alluvial soils produce trees of rank growth, which often bear enormous quantities of fruit, and yet

the highest priced fruits may be grown on the poorer soils. In the richest soil the plant food is seldom well balanced and present in the right proportions to produce the finest fruits, nor can qualities be affected by the use of fertilizers. If the field is normally fertile enough, as the coastal lands are, to produce great crops each year quality may still be affected by fertilization. On the other hand, the lands further back from the coast and further west, while not so fertile, may be made to produce fruit superior in quality and heavy crops by fertilization.

In this coastal belt and near it, in the orange belt of these two States, are to be found the heavy black soil, with almost no sand, and on this soil are fine, well-paying trees. In the chocolate lands, alluvial, and with more or less sand, are likewise to be found the healthiest sort of trees. The pine lands, with considerable sand, and back for more than a hundred miles from the gulf show that they will produce trees that are good growers and productive. The more gravelly lands further west, where the rainfall is not great, also seem equally well adapted to the orange, while it seems to be as much at home in the irrigated belt of the southwestern coastal region as it is under irrigation in California. Then no hard and fast rule about the kind of soil in which to plant can be set down. It is more largely a matter of handling the trees afterward than it is of the kind of soil they are planted in. If the soil is a good rich one to begin with, little need be added to it for some time, if proper care should be taken that proper plant food should be added for rapid growth and heavy bearing.

One thing is essential for the soil and for the orange orchard, and that is adequate drainage. The orange tree does not require a great amount of water. The lands should not be too wet and heavy, for if they are the growth will be slow, and the fruit crop will be light, as well as poor in quality. Drainage in the coastal belt of flat lands and high rainfall is essential to a good orange orchard.

A good orange orchard may be made on almost any sort of soil, but select the best you have, with good drainage, easy to handle, prepare it well, cultivate it well, fertilize and protect with cover crops, and use any other fertilizer when needed, and the result will be a good orchard.

PREPARATION OF LAND.

The heavy soils of the level region, the grass-covered lands along the coastal belt require much care to prepare for planting. They should be broken the year before, thoroughly disced and harrowed and pulverized, and the mass of grass roots given time to break up and rot. Such land, for the best orchard, requires six months or more. For this it should be well drained also.

The soils with more sand, loamy and without the heavy grass roots is not so difficult to prepare, but should be clean and in good condition, and with not too great an abundance of humus matter immediately about the trees.

Lighter soils, and soils under cultivation for some time require no more than ordinary preparation, as for the planting of any sort of trees or seed crop. But land should not be too clean and too free from humus matter and mulching.

In order to gain time in planting, as many wish to do, it is not necessary to have the lands broken, or cleared even, but the trees may be planted and the land cleared and broken and cultivated afterward. Care should be taken to have the ground about the tree, all that its roots will need for the first year's growth, in good condition for the striking out of the roots and the growth of a root

system, for the first year's growth of any tree is mainly below rather than above ground.

No time must be lost in clearing land so planted, for other trees will shade the plants and will take from them sunshine and moisture and plant food. Also the lands should be plowed and put in good condition and made available for the growth of the trees. All culture should be done with the aim of making as fine, healthy, well-fed and fruitful trees as possible.

NUMBER OF TREES TO THE ACRE.

A number of systems are used in planting, but the rectangular one is common. A field may be laid off in rectangules most easily, and cultivation in each direction can be done with most ease. The trees may be planted the same distance apart both ways, or a greater distance one way. Though the space between trees is not equally divided the citrus roots will penetrate and permeate all the soil, and will secure all the plant food within the top fifteen inches of soil.

The hexagonal system sets six trees equidistant from a tree in the center. The basis is an equilateral triangle. This system divides equally distance between trees. It sets about 15 per cent more trees to the acre. The quincunx system has a square or four trees, with one in the centre. The advantage of this is that the center tree can be taken out later as needed.

APPROXIMATE NUMBER OF TREES PER ACRE.

Distance	Rectangle	Hexagon	Quincunx
10x10 feet	436	501	831
12x12 feet	303	348	523
10x15 feet	290	.....	.....
15x15 feet	193	217	347
15x20 feet	145	.....	.....
18x18 feet	134	142	247
20x20 feet	108	124	199
20x25 feet	87	.....	.....
25x25 feet	70	81	126

The following may be regarded as approximately correct distances for planting for best orchard results, both in productiveness and growth of trees.

Kumquats	12 to 15 ft.
Satsumas	15 to 20 ft.
Grape Fruit	18 to 25 ft.
Other varieties of oranges	20 to 25 ft.

No set of rules can be given for distances, for soil, rainfall, fertility, stocks, protection from frost, spraying, etc., must all be considered. The effect of frost on densely populated orchards is not so great. The trees should be far enough apart to allow spraying and fumigating. Tree rows should be straight. In general it is better to have oblongs rather than squares.

Furrows or wires should be run both lengthwise and crosswise in the field, and a stake set where the tree is to be planted. It is not difficult to lay out rectangles for planting. Hexagons or Quincunix are more difficult. In planting either of these forms it is best to have a good draughtsman make a plot and give directions for laying off the rows.

SELECTION OF TREES.

First of all, buy trees from a responsible nurseryman. He has his reputation at stake, and can not afford to sell trees other than true to name and in

first-class condition. Should any mistakes occur he will always be found ready to rectify them. Some nurserymen guarantee the trees and will replace if they die within certain limits.

Purchase direct from the nurseryman. If possible, visit his nursery. It will pay you, if you plant to any extent at all, to do this. Do not buy from an agent, unless you are assured beyond all question of his responsibility, and that the nurseryman stands ready to carry out all that he tells you. See the conditions under which the trees are made ready and furnished you. Become personally acquainted with the nurseryman. You have no assurance as to the trees save his honor and integrity, and the better you know him the better for you. He will be glad to give you always all information as to varieties, planting, care, etc., that he can, for he is interested in having you succeed with your orchard and become a regular customer.

Purchase trees early, too. The supply is not equal to the demand, and lose no time in ordering for planting from a reliable nurseryman. "First come, first served," is true of the tree man. So never delay in securing trees for your planting.

The best citrus tree for planting is one with a root of three or four years growth, with a stocky, vigorous top of one or two years. Trees should not show signs of a poor stunted growth, though they may vary widely in the amount of growth for the year or two. Nor should the tree show signs of having been unduly forced to bring it up to a fair size. Nor should they show signs of sappy angular growth.

Generally speaking for the average planter there is no time saved in planting very large trees to have them come in earlier. In the end nothing is gained; frequently much is lost. Buy a medium or even small tree, with a good root system, give it care, cultivation, water when needed, and it will start off at once and make the best tree. The very best trees from a reliable nurseryman are the cheapest in the end, and poor stock is dear at any price.

WHEN THE TREES COME.

Trees are shipped by the nurseryman in boxes or bales. As soon as they come they should be unpacked and heeled in. A good shady place should be selected for this, a furrow made of sufficient length to hold the trees. Slope off the furrow to an angle of about 45 degrees, place the roots in the furrow, spread the roots out well, pack the earth about them and water.

When all is ready for planting take the trees from the furrow, a few at a time, as needed for planting, trim the roots and wrap them in a damp cloth or gunny sack to carry to the field. Neither *sunlight* nor *strong winds* should be allowed to strike the roots. Citrus tree roots are especially susceptible to injuries from these causes.

In trimming roots remove broken ones, cutting off with a smooth cut, sloping outward. The smooth cut heals quickly. The larger roots should be cut back freely. A goodly portion of the small, fibrous ones also; all of them if they have become dried. When there are two tap roots it is well to leave one longer than the other.

If possible to arrange it, the holes should not be dug till just before planting. The soil will then contain its natural moisture when placed about the trees. Care should be taken that the soil about the root of the tree is compact and clean and in fine condition. If the tree has large roots, rather long, and the soil is not deep make a large hole, and fill with soil, thus making a root bed of soil that

comes from within a half dozen or so inches of the top. Soil below this may have more or less of clay in it.

Trees should not be planted deeper than they stand in the nursery row, where there is much rainfall or they are irrigated often. In a dryer climate plant from 1½ to 2 inches deeper. Pack the soil well around the roots, but be careful not to cramp the roots in setting them. Give good soil about the roots for their setting and the first year's growth, so they will be undisturbed. If the soil is poor it is well to mix a pound of good commercial fertilizer with it as it is put in the hole. Water may be used when the hole is about two-thirds full, and after the tree is planted there should be a liberal supply. In irrigation or dry districts water should be used every ten or twelve days. Having applied the water, mulch the surface with leaves or grass to hold the moisture. Dry dust will do for this.

In hot, dry districts the trunks should be protected to prevent sunburn. Many will die from this, and many more will be stunted. Lath cylinders, or those made of yucca or paper serve the purpose. The trunks may be wrapped with straw or paper, or covered with whitewash.

The tops should be pruned back as soon as the trees are set. Do not retain too much top, for there is no gain in so doing. When the trees are taken from the nursery row more than half the root system is left in the ground. The top should be reduced proportionately. If the trees have a single shoot, without branches, they should be cut off with a sloping cut just above a node. If there are branches trim these back well, with two or three buds on each spur.

The Satsuma does not require much pruning of the top, as it is naturally a shrub, rather than a tree, and its natural tendency is to begin spreading from the ground. No further pruning than may seem well for starting the tree off should be given it.

If the trees are set in an orchard for them there is no need of setting stakes to protect them, but they should be protected if there is any danger of their getting broken off in any way or bruised, or the ground about them interefered with.

CULTIVATION OF ORCHARDS.

Owing to variety of soils and conditions there is great diversity of opinion as to methods of culture. The system adopted must meet the requirements of the soil in which they are planted and the rainfall. However, there are some broad principles that may be set down and followed with such variations as soil and climate show the careful tiller.

It is not generally difficult to keep the lands in good condition. Less labor is necessary than for the lands of other orchards in other parts of the country. The trees seem to thrive some times without any cultivation, and there are even found some men who will say that an orange tree needs no cultication at all after it has attained a growth of a few years. True it may not die and may bear heavy crops of fruit each year, but it shows, when compared with a tree of the same age in a well-cultivated orchard, that it pays well to continue cultivation.

After the ground has been put in fine condition, either before or after planting, the question comes as to how often and when it should be cultivated. It should be cultivated as often as necessary to keep it well pulverized so that it will hold the moisture and allow the air to percolate through it, supplying oxygen to the roots and setting free plant food. In well cultivated soils decomposition of vegetable matter goes on more and nitrogen for the plants is set free more quickly.

The basis of "Dry-Farming" is the fact that water in the soil is to be found as a film surrounding the particles of soil. Then the more numerous

these particles are, provided they do not become dust, the more water there is available for keeping the soil in good condition. Loose, open soil permits the rain to penetrate. If the surface is dry and hard water runs off. When the soil is well stirred water is held when it rains, and also there is less loss by evaporation because the top of the soil acts as a mulch. Frequent shallow cultivation then keeps the water within the soil and prevents its too rapid escape by evaporation.

In the area of greater rainfall along the gulf coast the main point is to keep the soil well stirred so that it does not become hard and cake where there is little sand in it. Where there is more sand it should be stirred frequently also, in order to keep the water in the soil well distributed. Further west, where the rainfall is not so great, in Bee, Victoria and other counties, yet it is about 30 inches a year, the average in Illinois, and where the sun shines hot, it is best to cultivate the lands so that they will always be in fine tilth and all moisture conserved for the tree roots. Irrigation in these sections is by no means necessary, and the horse and cultivator are all essentials required for the trees. However, in the district irrigation belt in Southwest Texas irrigation is necessary, and the trees should be watered as the ground seems to need it.

The orange does not need so much water, and the finest flavored fruit comes from those regions where the rainfall is just enough to keep the trees in healthy growing condition, provided the water that falls is properly conserved by the right sort of soil culture. Along the coast, where the rainfall is 50 inches or more there is danger of getting too much water in the ground, unless it is well drained, an essential spoken of under the heading of "Preparation of Soil."

Some growers keep the ground perfectly clean the year round. There is little to recommend this. The soil soon becomes lacking in humus matter and depleted of its fertility. No amount of fertilizers will restore it when too much humus is lost. Soon the trees show the effects of such culture in becoming unhealthy and ceasing to bear large crops of fruit. If clean culture is adopted the humus must be restored in some way, by leaves or mold or straw. But it is easier to retain the humus than to restore it after it has been exhausted.

Humus, one of the most important constituents of plant growth, should be increased rather than diminished by methods of culture. Ground denuded of its natural growth and left exposed to sun and rain soon loses its fertility, and becomes dead and unproductive. This holds true of the orchard in cultivation as well as of the field. The soil is the place wherein the roots get the food which they convert into tree and fruit. Long-continued clean cultivation removes from the soil the humus, wherein the tree finds its essentials for food, and soon makes the soil nothing but an unproductive sand and clay bank.

Humus is the product of the decay of organic substances. It is the intermediate stage between the revolution of the organic substance into the chemical. It is the most important substance found in any soil, and may be taken as an index of fertility. Barren soils lack this substance, but not necessarily mineral ingredients.

Soils rich in humus retain moisture, are more porous, air circulates more freely, and so plant food is held in better solution. Humus also contains from three to twelve per cent of nitrogen, and are also usually well supplied with phosphoric acid and potash.

Where commercial fertilizers are used, and they will come to be used in Texas and Louisiana as orchard cultivation becomes more of a science, humus is necessary as an intermediate for the conversion of the fertilizer from an

unavailable state for plant food. It is also the media in which bacteria work, and holds plant food in solution till it is used up by the plant.

(More will be said about this subject under "Cover Crops.")

METHODS OF CULTIVATION.

Ground should be prepared well before planting. It should be plowed deeply, roots of grass and weeds broken up, and should be disced and harrowed till the vegetable matter is converted into humus. If this is not done before planting it must be done right up to the tree holes the first season after they are planted. After the young orchard is planted the ground may be plowed deeply, but not closely to the trees.

Tree rows should be cultivated comparatively shallow. This will have a tendency to send the roots deeper into the soil as they spread out from the tree. If the soil is plowed the depths should be varied from year to year so as not to create a hard and compact layer below a certain depth.

With the rich soils and the deep ones of most of the coastal belt deep plowing is not so very necessary. From six to eight inches is usually about right. This should be increased from year to year till a depth of twelve or fourteen inches is reached and formed into a good root bed. This may sound radical and useless to the average farmer, but behind this statement is the experience of the best cultivators in other States.

During the period of most active growth cultivation should be frequent. When the soil is damp and heavy such frequency is not necessary. If the weather is dry cultivation should be had every ten days or so to preserve the moisture. The cultivator should be kept going all the time. A light harrow or weeder is all that is necessary. It is always best to cultivate as soon as possible after a rainfall. This retains the moisture. Where the orchard is irrigated it should be cultivated as soon as dry enough.

Weeds should not be allowed to grow during the period of cultivation. They utilize too much water that the trees need. After cultivation for the season is done with a proper cover crop should be grown.

In this region every effort should be made to have the trees dormant during the entire period when there is danger of a frost. It takes very little frost to injure a tender, sappy shoot, and a dormant tree can not be injured save by a hard freeze. Cultivation should have as its aim also the making of the tree dormant in the fall, to remain so till after the danger in February and March, the real time of danger in this belt. The distinct advantage of the trifoliata stock is that its dormant period is a long one, and so the likelihood of its injury is small.

It is difficult to have citrus trees thoroughly dormant, for they are by nature evergreens. Cultivation will help to keep them dormant, even though the tendency is for them to respond readily to the warm days and weeks of the winter months in the coast country. Cultivation should not be continued late in the fall. Nor should fertilizers rich in nitrogen be applied late. Nor should grass and weeds that have grown up after cultivation has stopped in the fall be allowed to stay during the winter. In other States it has been shown that frost is more likely to injure the trees when there is among them dead grass and weeds. Certainly there is danger of fires injuring them.

The implements used for cultivation must be adapted to the character of the soil. Each farmer knows what is best to keep his soil in good condition. Cultivators, light or deep, can be used by him as his soil seems to need. For

shallow cultivation there is no better harrow than the Acme. Also a weeder and a light harrow do well. For deep work a disc harrow will do the work well, as will a Planet, Jr. Cultivation should be in the hands of a careful man. The ends of the whiffletrees should not be allowed to scar the trees. Cultivation should be done intelligently and thoroughly.

COVER CROPS.

A cover crop at certain seasons of the year is an important factor for the orange orchard. It serves two purposes, to keep a requisite amount of humus in the soil, and to protect the soil during certain seasons. In fact, the advantages are many. They may be all named.

Humus is added and water-holding capacity is increased. This latter effect is of special value where the rainfall is not so great.

The soil is opened up deep so that hard layers are not formed, and the soil does not become too compact.

In the coastal belt where the rainfall is great and drainage a problem a cover crop aids in removing too much moisture from the soil.

It prevents leaching of nitrates where there is excessive rainfall during certain seasons, and promotes nitrification.

It adds plant food, through the leguminous crops, and breaks up and renders available the plant food in the soil.

There are two classes of rover crops, those that collect nitrogen, the leguminous plants, those that consume it.

To the former belong alfalfa, cow peas, clover, velvet beans, vetch, lupines and a few others. On the roots of these plants are nodules formed by bacteria, which find entrance to the roots through the root hairs. These bacteria collect and store nitrogen of the air in the tubercules formed on the plants. This nitrogen then becomes available for the use of the tree roots. These tubercules give up their nitrogen and disappear.

To the latter class belong rye, oats, rape, grasses of various kinds; in fact, all plants for cover crops not belonging to the legume family. These plants only give back what they have withdrawn. They also add humus to the soil.

The value of a cover crop depends largely on the time it is plowed in. In our hot climate it should not be plowed under when green, but should be allowed to become partially dry. If plowed under green it tends to sour and so become injurious to the trees and land.

Cow peas are well known, and their value as a cover crop every good farmer knows, and he knows also how to handle them. The cover crop should be gotten out of the way by the time the picking season begins. Cow peas are subject to the nematode, a worm that is injurious to most tree roots also, but not to citrus tree roots. The peas may be gotten rid of by mowing them and allowing them to rot on the surface or by harrowing them in.

The velvet green makes an immense growth. In full vigor it will cover the ground two or three feet deep with a mass of vines. It is difficult to handle in a region where there is no frost to kill it in the fall, as it continues a rank growth till late. It may be mowed and left to rot on the ground. It collects nitrogen in large quantities. In the orange orchard it will add fully a hundred pounds of nitrogen to the acre.

The seed should be sown in May. Cultivation should be continued for three or four weeks after planting, and the weeds should be kept down till the beans are well started. It is better to sow in drills, four or five feet apart. They

should not be planted closer than six or eight feet to the trees. Care should also be taken that the vines do not run over the small trees and smother them.

Crab grass and the cover crops that are not leguminous are valuable as cover crops in that they serve all purposes, save bringing nitrogen. Some growers may prefer supplying the nitrogen.

These points in cultivation are somewhat new to this region from the fact that very little attention has been given by any one to the study of soils and crops on them and the needs of plants for best growth and fruiting.

FERTILIZERS.

Proper food material for the making of the tree and of the fruit must be supplied. It is not enough to say that the soil is rich and deep and needs nothing. No soil is inexhaustible. The richest coast country soils in time come to need many constituents for the growing of heavy crops of the best quality of fruits.

On quality of the orange depends more liberal returns to the grower than is the case with almost any other fruit. The orange is a dessert fruit, and is eaten in its natural state. There are no secondary products. It must appeal to the eye and to the palate direct. Its qualities can not be changed or supplemented. The only modification in its quality that can be made is through the food on which the plant that produces the fruit grows. Therefore the matter of fertilization is an important one.

It will be some time, however, before much attention is given to this subject in the orange section now being developed. The careful grower, good student and practical orchard man will study these problems and see that his trees have the right constituents for the making of oranges uniform, of good size, smooth, well-colored, and of the best flavor. The sooner the study of this is made the better the orchard will pay the grower.

The orange lands of Texas and Louisiana are naturally so fertile that little need be added save just the right constituents for making the individual orchard the best. However, when all the essentials of plant growth seem to be present it is often found that something will add materially to the quality as well as to the yield. The intelligent orchard man wishes to apply to his orchard the plant food required by the crop to be grown. In order to do this he must know what his soil has in it, and what the fruit requires.

The fruits of California and Florida differ from each other in character and composition, and it will be found that those of Texas differ from the fruit grown in the States named. The California orange shows 50 per cent more nitrogen and 50 per cent less phosphoric acid than does the Florida. There is more than twice as much potash in the Florida fruit. The potash makes the Florida orange superior in sweetness and flavor.

The composition of any soil as determined by analysis has little bearing on practical methods of fertilizing. It is impossible to determine the amount of any plant food that will become available or will be used by the crop during its period of growth. The chemical condition of the soil is of less importance than is the physical condition and the constituents.

The food requirements of citrus fruits differ from recognized requirements of other crops only in amount and proportion. Potash, nitrogen and phosphoric acid are demanded by the tree in excess of the ability of the soil to furnish, and they need to be supplied by the grower. His concern is to know how much and in what form to apply them.

Lime is needed, and its direct effect is to produce the desirable thinness of skin. Phosphoric acid is more evident in its effect on the tree than on its fruit. Also it goes largely to the seeds. Lack of sufficient of it in the soil is frequently shown in a mottled or variegated appearance in the newly formed leaf. Nitrogen forces vigorous growth. This shows in wood, leaf and fruit. Absence of sufficient nitrogen shows in paleness or yellowness of leaf, scanty foliage and apparent lack of vigor. Abundance of nitrogen results in luxuriant growth, abundant glossy and dark colored leaves. Heavy, juicy fruit is another result of plenty of nitrogen supply. Dry, light fruit, with superabundance of "rag" is an indication of a lack of nitrogen. Excess of nitrogen causes the ends of the twigs to die back, and the fruit becomes thick and rough skinned. Potash exerts a most decisive influence on the fruit. It affects the color, sweetness and flavor of the fruit, and the ripening or hardening of the wood. Lack of potash shows in immature wood and in consequent susceptibility to injury from cold. Over one-half of the ash of an orange is potash. Experiments and experience show that the direct influence of potash on the quality of fruit is very great. The influence of potash on wood growth is apparently greater with the orange than with any other kind of tree, and in this respect it has a special significence. The new growth of orange wood is normally not cylindrical. The young twigs at first are flattened on two or more sides to an angular form, usually approaching a triangular shape. Toward the end of the first season this condition disappears usually, and normal development succeeds. When there is too much ammonia for the trees this form continues and the development of round branches is delayed. In orchards deficient in potash or with too much ammonia branches two years old showing angular sides are much in evidence.

The condition of the young trees thus shows indications of the soil constituents or lack of them for the making of the best trees and the best fruit. The orange grower must feed his plants for both tree growth and fruit. He must observe his trees and from their appearance decide what constituents are needed. The young orchard needs fertilizing for the tree growth alone, while the older orchard needs fertilizing for both tree and fruit. In order to get the best results the grower must know his trees and be ready to add in some form the materials that seem to be lacking. When the trees come into bearing he must further study what is needed for the making of the best fruit. The less quickly available forms, bone meal, sol phosphate and Thomas slag may be used for tree making materials. For regular feeding and quickest results acid phosphate should be the standby.

The best form of potash to use is Sulphate of potash or sulphate of potash-magnesia. The latter is best for fruiting trees on account of the magnesia it contains. Hardwood ashes can also be used to good advantage occasionally, as the alkali in the ashes will neutralize any acid that may have accumulated in the soil, and this will better enable the tree to take up the plant food placed within its reach.

In selecting the form of nitrogen the greatest precaution is needed. Stable manure should not be allowed near orange trees. Rank growth, thick skins, much "rag" and inferior flavor are the results. Splitting and dropping, and even die-back are the results under aggravated conditions. Other organic forms of nitrogen, such as cotton-seed meal tankage and blood, possess much the same tendency, and should be used with great caution. Nitrate of soda is the best form in which to apply the nitrogen.

An important secondary effect of fertilizers is on the soil as regards moisture. Nitrate of soda and kainit both materially increase capillary attraction. More water moves up from the lower strata and thus becomes available for the trees. These salts increase surface tension, and consequently the capillary movement of the water. This is a point so important in some regions that it may well affect the selection of a fertilizer. Organic manures have the opposite effect and increase the dryness of the soil.

Of the three requisites, phosphoric acid, nitrogen and potash, the last named is far more important. Experienced growers are able to pick out the fruit from orchards where this essential is found in sufficient quantity.

The orange blooms in the spring. The fruit grows on wood grown the preceding season. It is thus apparent that the fertilizer for the bloom and fruit must have been consumed the previous season. Fertilizer should be applied at least twice during the year. Three times are better. February, June and September are the months. The first may be called the bloom, the second the fruit and the third the wood fertilizing. The first two applications should be strong in nitrogen; the final one should be mainly potash. Fertilizer should be so applied that the bulk of it will be, not near the tree, but out where the roots can take it up most quickly. It should be sowed broadcast, and should then be harrowed in. The first two or three years it should be applied close to the tree, of course, for the roots have not yet reached out very far. The roots will seek the fertilizer, and the larger the circle of roots will become as the fertilizer is spread and the root systems extend in search of it. This also gives a greater area from which to draw moisture and natural food

The subject of fertilizers is one that must be studied carefully by the orchard man who wishes best results from his trees.

WIND PROTECTION.

Orange trees exposed to winds, as is the case along the coastal region, should be protected by windbreaks. This prevents the tree from whipping itself to pieces. The salt-laden atmosphere is not injurious to the trees necessarily, but the continual beating is. Rapid growing, heavy foliaged trees should be planted. The camphor tree makes a fine windbreak. The eucalyptus makes a rapid growth, and with some smaller tree as an aid it makes a quick and good protection. The catalpa tree is also first-class. A belt of natural timber, where there is one, should always be left as a protection.

PROTECTION AGAINST FROST.

It must not be forgotten that the orange is tropical in nature. The great advantage of the trifoliata stock is he fact that it gives a more complete and longer dormant period than any other stock. Protection against frost and cold is to be had through methods of cultivation and handling and through artificial protection.

A statement of the conditions under which the trees in Florida were killed will illustrate. On December 29th, 1894, the temperature fell at Jacksonville to 14 degrees, the coldest known for 60 years. The trees were dormant, or fairly so, and little injury resulted. This cold was followed by three weeks of extremely warm weather. The trees at once began to grow to repair the defoliation caused by the cold. By the end of the first week in February they had put out tender shoots, buds and half-formed leaves. They were full of sap. On February 8th the temperature again dropped to 14 degrees and the trees were all killed. It was not so much the cold as the unusual conditions that brought about the damage.

The tree must be kept entirely dormant, or as nearly so as possible from the first of December till the first of March. Cold weather here is usually about the middle of February. The following means will help most effectively to this end:

Omit the working of the trees from September till February.

Exclude all nitrogenous or ammoniated fertilizers during this period.

Root-pruning, carefully practiced around one-quarter of the tree is conducive to dormancy.

Stocks for planting should be selected with reference to dormancy. Herein lies the advantage of the trifoliata.

Living trees and large bodies of water are several degrees warmer than the surrounding air. The strip of land along the southern bank of the lower Mississippi is probably the richest natural orange region in the United States. Its warm and even temperature is due largely to the protection of a mile of water between it and the winds that come from the north. A rice farmer in Louisiana floods his orchards from his pumps when a cold and frosty night comes, and thus protects them.

The hilling of the trees, as practiced by some of the most successful orchard men, has in view the keeping of the trees dormant and not subject to starting growth while there is still danger of frost. It keeps the ground about the roots cold and so prolongs the dormant period.

Artificial heat is used in both Florida and California. In time it will come to be used in Texas and Louisiana when needed, and the growers recognize the value of their orchards, and that they can afford to take no chances with their trees. Slow fires or smudges, of straw or moss, make a smoke, and this settles over the grove and prevents a formation of frost. This protects the trees after the sun rises, for it is rather the thawing too quickly more than the actual freeze that hurts. Dry fires, of coal or wood or oil, are used also at intervals through the orchard. These fires raise the temperature a few degrees, but more important, set in motion currents of air so that frost is not formed. The cost of thus protecting an orchard is not great when the value of the trees and fruit is considered.

DISEASES AND REMEDIES.

The number of diseases attacking citrus fruits is not nearly so large as those attacking most other fruits. Some are due to negligence, while others are associated with fertilization and cultivation. Still some may appear under the best care. Many of the diseases are due to fungi. These attack various parts of the tree, roots, branches, leaves and interfere with their functions, and eventually kill the part or the entire tree. These fungi are spread by means of spores, which are scattered by the wind and rain, and sometimes by heat and moisture. Another class of disease is connected with the cells of the plant and the life activities of the cell formations.

FUNGUS DISEASES.

Foot-rot or *gum disease—mal-di-goma*, is known wherever orange trees grow. In Florida it has destroyed the sweet seedlings, and is mainly responsible for the discontinuing of the sweet stock for propagating purposes. It is clearly marked and not likely to be confounded with any other disease. It is confined to the crown and main roots of the tree, extending a foot or so above the ground and downward along the roots. Its presence is indicated by an exudation of gum, which forms in drops on the bark covering the spot. The outer cortex becomes brownish and the inner decayed. The affected part emits a fetid odor like that

of a decayed orange. The plant strives to overcome the disease by cutting off the infected part and making a wall of new tissue. The bark then dries up, breaks away and drops off. Though the tree may continue to bear fruit it does not appear healthy. The leaves become yellow, the twigs and young branches die. Unless the tree is cured in some way it soon dies. Sour orange, trifoliata, rough lemon and pomelo are very risistant to this disease, while sweet orange and lemon are very subject to it.

The specific cause of the disease is in doubt, but it appears to be a fungicidal growth. Deep-setting, wet, soggy soil, rank, organic fertilizers, soil underlaid with hard pan, faulty drainage, shaded conditions, are all contributory to its spread. A healthy tree is more likely to throw it off.

As a remedy remove any of these injurious conditions; cut out all diseased tissue and burn it; paint the freshly cut wood with a good disinfectant insecticide solution and disinfect all implements that come in contact with the diseased tree.

Scab, lemon scab, sour orange scab, attacks the sour orange, the lemon, the Satsuma, and sometimes the pomelo and kumquat. The leaves, twigs and fruit become scabby and warty. Sometimes the leaves are twisted and drawn out of shape and so can not fulfill their natural functions of respiration. Under the warts on the fruit is an abnormal thickening of the tissue. The warts are first yellowish, then grayish and finally they become dusky and black and crack and open. The specific cause of the disease is a fungus. The spores are small, smoky in color, and borne on brown colored filaments. When mature they become detached, and are carried by the wind from one tree to another. Falling on the young leaves the spores germinate by ending out a delicate slender tube which produces the well-marked diseased condition of the leaf.

The scab can be controlled by using a copper spraying solution, Bordeaux mixture or ammoniated solution of copper carbonate. Spray three times. First when the petals have fallen from the first blossoms and two others inside of six weeks. If these are not enough to protect the young fruit further spraying should be done.

Frequently round dead spots are to be found on citrus leaves. An examination shows that there are minute dark spots over the dead yellowish spots. These dark points contain the spores of a fungus which causes the trouble. This fungus causes the dying back of the twigs of citrus trees, the death of lime-blossoms, anthracnose of the lime, and black-spot diseases on the rind of the lemon. This disease can be held in check by spraying with Bordeaux mixture.

A *fungus* frequently cause a *ripe-rot.* This shows as a yellowish cover of dust-like, bluish powder. This fungus is closely allied to the blue mold that forms on bread. The powdery mass is composed of innumerable spores. The filaments or roots of these spores penetrate the tissue of the fruit. After the filaments have grown some time they become beadlike strings of spores. The spores are the bluish, powdery mass. From this spore a filament is sent out, and if it can penetrate the fruit it grows and develops more spores. A slight bruise or the injury of an insect is sufficient to enable the spore to begin to spread through the fruit. Hot, damp days and nights are favorable for its growth also. It may spread from orange to orange in an improperly cured and tightly packed box, or from orange to orange as they touch on the tree.

The remedy for this is thorough curing and drying. A good quality of wrapping paper should be used. Culls and decayed fruit should be destroyed. If the packing house is infected it should be closed and fumigated by burning sulphur.

Sooty mold is widely distributed. It occurs as a sooty-black covering on the leaves, fruit and twigs of many plants, and is clearly associated with various insects belonging to the families of aphidae and the coccidae. It is found with all the scale and allied insects that exude honeydew. It feeds on honeydew. The insects named are gregarious in their habits; the honeydew accumulates in these spots and so the fungus appears as a black covering. This covering is vegetable threads, and develops wherever sufficient honeydew is found.

When it follows the attack of the white fly it is most dangerous. The white fly spends the greater portion of its life on the under side of the leaf, the honeydew from it falls on the leaves below, and the fungus spreads through this and soon the leaves, twigs and fruit come to have a black, sooty covering. This covering prevents the entering of the sunlight to the pores of the leaves, shuts off their breathing, and so hurts the tree. The immediate damage is to the crop. Ultimately the trees perish. When this fungus is abundant the fruit is so colored by it that it must be washed before marketing.

No treatment for the fungus alone can be recommended. The insects should be destroyed, and then the fungus will disappear of itself, for when there is no longer honeydew it perishes.

Flyspeck or *sooty fungus* covers the rind of the fruit to a greater or less extent. When the rind is badly affected it gives the fruit a blotched appearance. This sooty covering must not be confused with the attacks of insects on the trees, as is the case of the soot on the leaves, twigs and fruit spoken of above as due to the white fly and other insects. The cause of this is a fungus. It is common to the apple also. So far as is known no damage is done to the fruit, but it is made unsightly. Nearly all traces of this fungus may be removed if the fruit is washed, and this is the best treatment. It appears about the time the fruit matures.

Lichens are found upon trees, stones, logs, etc., in most moist regions. They are not parasitic, but do injury to trees by preventing free access of air to the tree trunks, and by forming a harbor for insects. They are never so plentiful on trees in healthy condition, and they are very unsightly. There is also a lichen that is sometimes found on the leaves of citrus trees. It takes the form of small ashy-gray dots and blotches on the upper surface of the leaves. This lichen injures the tree by obstructing the breathing processes of the leaves and the access of light. As a remedy leaves should be sprayed and trunks should be scraped or scrubbed clean. Soap suds will serve for the scrubbing.

PHYSIOLOGICAL DISEASES.

Die-back is found in all citrus districts. It attacks every variety. Conditions producing it have been spoken of already under the head or Fertilizers. The diseases can be detected at once. The twigs die back for several inches, and eventually the larger ones are affected. The new growth is nipped off. Fruit drops off. The tree tries to remedy itself by water sprouts, but these too are affected, and at last the tree dies.

It is not a fungus disease. It is rather a disorder of the tree. The only treatment for it is to study conditions of soil and fertilization and bring the trees into a healthy condition. In damp ground the main thing as safety from the effects of this disease is good drainage. Fertilization and cultivation of the right sort are most effective.

Blight is the most dreaded and worst of all diseases. Blighted trees appear to be suffering from drought, or look as if they had been recently transplanted.

The leaves wilt, droop and finally fall off. In some cases the disease works very rapidly; sometimes slowly. The cause of the disease is not known. Trees at any age may be attacked. There is no external evidence of cause. It seems to be rather some derangement of the internal functions of the tree. Pruning does not stop it. It spreads from one tree to another, and the best method is to cut out and burn trees that are affected. The only way to combat it is through the soil, and no method has yet been found.

INJURIOUS INSECTS.

Biting insects; that is, those that eat the leaves, are not so numerous or so injurious as the class which cling to the leaves and suck the vitality out of them. *Grasshoppers* do damage sometimes by eating the foliage off, but this has never been a damage of any extent worth while in the coast country.

The *orange-dog*, a large, ugly caterpillar some times feeds upon the leaves. It is a dark, brownish black worm, two or more inches in legnth. There are large blotches of dirty white When disturbed it emits two horns, or feelers, and a very disagreeable odor. It is an enormous feeder, and a leaf is soon eaten by it. The damage is done while it is in the larval state. After the worm is grown it crawls to some tree, or log, and goes into the chrysalis stage. In about two weeks a butterfly is hatched, gorgeous black and yellow, and six inches across the wings. The females deposit four or five hundred eggs a season, on the tender shoots and twigs, and there are four or five broods a season. As soon as these hatch the damage begins by the eating of the leaves by the young caterpillars. This insect may be gotten rid of by picking and destroying the cocoons, or a spray of paris green; four ounces to fifty gallons of water, will kill the caterpillars.

The *purple scale* is widely spread. It is one of the largest of the scales. One varitey is called the oyster-shell bark louse, and feeds on apple trees. The general outline and markings suggest the oyster shell, hence the name. The males are smaller than the females. The eggs are white and very minute. The newly-hatched larva is white, about one-tenth of an inch in length, with fiery eyes. This larva soon fastens upon a leaf or twig and sends out a film of threads. About three weeks after hatching the true scale is begun. Three or four weeks later a second moult is begun and the female nine or ten days later begins to lay eggs. The eggs are deposited beneath the female, and in about a week the young begin to appear. The male moults earlier, and becomes a fly by the time the female is through the first moulting. There are four generations a year. In March and April, June or July and September are usually found the most scales. A thorough spray with kerosene emulsion or caustic potash or whale oil soap will destroy them.

The *red scale of Florida* infests branches, leaves and fruit. It may be treated with the same solutions. It is not so injurious as the purple scale. *California* also has a red scale which has proved to be a troublesome pest. No predaceous enemies have been found to control it, so that spraying is the only remedy. The same solutions are effective.

The *long scale* is one of the very injurious ones. It is of a more linear shape than the purple one. The female is brownish, about one-tenth of an inch in length. When crowded the scales take all sorts of shapes to fit their surroundings, and many become so dwarfed and malformed that it is difficult to recognize them. The young are a translucent wax in color; as they grow older they become purple. The male is smaller than the female. It becomes a minute

two-winged fly. The life history of this scale is like that of the purple scale. The same remedies may be applied to destroy them.

The *chaff scale,* thin, light and straw-colored, is found mostly on the trunk and larger limbs of the tree. Sometimes it spreads to the fruit and leaves. It resembles the bark in color and is frequently overlooked. It can be destroyed by using a good scale destroyer and spraying thoroughly.

The *orange scale,* found on the twigs and leaves, is very abundant in Louisiana, and may become widely spread throughout Texas. It can be seen easily, and can be destroyed by a good spraying with a first-class scale destroyer.

The *turtle-back scale* grows to about one-eighth of an inch in length, is broad and oval. It gets its name from its resemblance to the turtle. The young is yellowish in color, and always settles upon bark and leaves of a tender growth. The insect increases the most rapidly when the young twigs are tender in the spring and early summer. Later they disappear. They do not seem to be able to pierce the bark of the older twigs. They may be destroyed by a good spraying.

The *black scale* is larger, nearly black in color. The young feed upon the twigs and leaves. There is generally only one brood a year. This scale feeds upon other than citrus fruits. It can be destroyed by spraying with a good scale destroyer.

The *wax scale,* so called because it is covered with wax, and under this covering the eggs of the young are hatched, is not very dangerous. It feeds upon other than citrus fruits also. It is large enough to be seen readily. Resin wash, whale oil soap or kerosene emulsion will destroy it.

The *barnacle scale* is like the wax scale, save it is differently marked. It is also larger. It is more rare, and may be destroyed in the same manner as the preceding.

The *cottony cushion scale* is the one that did so much damage in California. Neither fumigation nor spraying were effective. It had a natural enemy, however, in the lady-bug, brought from Australia, and this bug has always checked it. This bug must be introduced where the scale makes its appearance.

The *mealy bug* is also common in other orange growing States. It will come to this region in due time. It may be controlled by a strong insecticide and thorough spraying. It is about one-eighth of an inch in size, and dull brownish in color. The young may be found on the under side of the leaves. These bugs exude honeydew, and the red ants scatter them. Destroy the ants.

The *White Fly.* The white fly is the worst dreaded of all pests for citrus trees. It reproduces very rapidly, and passes through the various stages of development from the minute egg to the fly, four moults, in a comparatively short time, and the number of eggs laid by one female is enormous. The young larvae crawls about the leaf, but are visible only on close examination. The female is about one-twentieth of an inch in length, and the male somewhat smaller. The fly can be destroyed by fumigation or through spraying during the pupal stage. Use a good scale destroyer solution.

Mites of various colors are also pests injurious to the tree and to the fruit. They injure the fruit in size, and it does not develop well. They are usually in greater abundance on the under side, and so this side is given a rusty appearance. The mite may be controlled by spraying with solutions of sulphur and caustic soda, or containing these ingredients in goodly quantities.